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Double Wall Construction

From the Editor . . .

Images of Stanley Kubrick's film 2001: A Space Odyssey come to mind as I look around our world today. The film's story deals with encounters between humans and mysterious black monoliths that are apparently affecting human evolution. The opening scenes show humans examining a mysterious monolith.

That film was released in 1968 – a time when computers were large complex mainframes and personal computers were still simple and not much more than expensive typewriters and calculators. Fast forward to 2014. Miniaturization has changed those mysterious monoliths into small tablets that fit into a pocket.

Today's tablets do things that those of a certain age could never have dreamed of. Today, we live in a digital age where everything we do seems to be controlled by computers – it seems that we can't live a day without peering into the little screens. They are not just a telephone, but also a mailbox, camera, calculator, music box, navigational aid and entertainment centre. They also provide access to a wealth of information that's been digitized.

Construction work is one activity that can't be digitized – we create physical spaces in which we live and work. Even so I'm amazed how quickly the new digital technology has changed the construction site. Not so much the physical activity on site, but the support it provides by enabling quick documentation of progress, access to technical documents, specifications and communication with other team members.

But the digital age has a hidden side to it that we don't really pay attention to, and that is the massive infrastructure required to keep it operational. We pay a modest fee (and grumble about it) to a provider for access, and each year or two we upgrade our tablets to the latest and best gizmos we're told we need. We do it without really paying much attention to what it is that we're buying, and we have even less understanding of how it all happens.

But it is well worth to stop and consider how the system we plug into comes about. Unlike in the past, gatekeepers can be distant and unseen. You're reading this on a piece of paper that has been widely distributed – you need to get it delivered, but it's around and accessible for as long as the piece of paper survives and you've got light with which to see it. No matter what happens anywhere else, you'll always be able to find it wherever these papers are stuffed – maybe gathering dust in some corner. Libraries, public and private, have been knowledge repositories for centuries.

But digital access is not the same – it's not as permanent as we may think it is. When the battery runs out, you'll get nothing until it gets recharged. And we've seen many cases around the world, including in Canada, where access may be denied and material has been purged. Some may say that material, once loaded onto the internet, remains out there forever. However, only techie geeks would have the savvy to find it – the average user does not have the expertise or will.

Reading this far you may be wondering what any of this has to do with the construction industry. Actually, quite a bit. As we get comfortable with on-line access to information, we may be lulled by the seeming simplicity. But we've seen access to some materials reduced, as documents disappear from digital libraries. CMHC has removed some publications and research reports that previously were on-line. I've heard other departments and governments doing the same – not just research documents but even copies of legislation that should be in accessible archives.

The recent cyber intrusion at the National Research Council has meant that NRC documents, including National Building Code and CCMC evaluation reports have not been available for some time. In the meantime complex time-consuming work-arounds have been developed at the NRC until the IT infrastructure is rebuilt – and that could take up to a year.

Think about that when you next pull out that phone from your pocket and expect to find the world there.

Richard Kadulski,
Editor

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Double Wall Construction: a Historical Perspective

Harold Orr

In 1973 the effects of the OPEC Oil Embargo effectively doubled the price of crude oil and caused massive shortages in the U.S. The result was that there was a worldwide scramble to find lower cost oil or alternatives.

At that time, to get research funding one needed to insert the word "solar" in the title of any proposed project. With this in mind the provincial government of Saskatchewan asked the Saskatchewan Research Council (SRC) to "design and build a 'solar' house appropriate for Saskatchewan."

At the time the SRC did not have a building group and no experts in building or construction so they asked a number of other agencies to provide the necessary experts. The University of Saskatchewan (U of S) in Saskatoon had a long history of building research starting in the 1920s with Professor Greg, Dr. Green, and more recently professors Besant and Schoenau. The Canadian House Builders Association had a number of well-qualified builders in Saskatchewan. Also on the U of S campus, the National Research Council's Division of Building Research had the Prairie Regional Station that was doing research in this field. Each of these agencies was asked to provide experts to sit on a committee to fulfil the government's request for a solar house.

The first hurdle the committee had to jump was the word "solar." Regina is at 50.5° north latitude with a severe continental climate. Although the sun shines in the winter there is very little heat available from the sun during the November to February period. So if you are going to heat a house using solar heat you need a house that needs very little heat and also has some means of storing the heat for a long period of time.

One of the early solar houses built about this time had a steep pitched roof aligned east and west so that the whole south side was used for the solar collector and the whole basement had a storage tank for heat storage, but this house was more than 700 km south of Regina in a different climate zone. We quickly realized that we could not store enough heat in water, hot rocks, or other materials that would provide heat to keep a conventional home warm in Regina's climate for more than about 40 days, but we needed at least 120 days of heat. At the same time we would lose the basement so that we were not really comparing apples with apples.

What then was the solution? We looked at just reducing the heat loss of the house. Then the internal heat sources (heat given off by cooking, lights and occupant activities) could provide a major portion of heat. When we look at where the heat is lost in a home we find that about 2/3 of the heat loss can be reduced by adding insulation but about 1/3 is due to air that leaks into and out of the house and this is not affected by the amount of insulation. So some other approach would be needed to solve this problem. We felt that if we could reduce the losses from the house by 75 to 80% we would not need the cost of going to active solar.

Our first approach was to try more insulation. There were several homes that had been built using 2x6 studs with about three times the current insulation, but we knew that these houses still used about ½ the energy of conventional houses so we had to take a quantum leap to design a super low energy house.

Our approach was to use a double wall where we used R-12 in both walls and R-20 between the walls. This was about 6½ times the normal insulation and we tried to achieve similar reductions in the other heat loss paths. R-60 to R-80 was easy in the attic as we only needed to raise the heel of the roof truss. Insulation of the floor caused a minor problem because we could not use conventional insulation below ground where it would get wet, so we decided on a floor above an unheated crawl space. This also solved another problem; basements in Regina are always a problem because of soil conditions, and this would allow about R-35 in the floor vs. R-0 which was the current standard. Windows created another problem since there were no really good windows at the time, so we decided to use insulated shutters, although it was recognized that this created several other problems.

This left the last 1/3 of the heat loss due to air leakage. I had been making small rooms air tight

Harold Orr is a retired building scientist from Saskatchewan. He was a driving force behind the Saskatchewan Conservation house that set the groundwork for low energy housing in Canada and around the world – starting with the R-2000 program.

with 6 mil poly for studies in air infiltration and I felt that I could make this house much tighter than conventional houses. I volunteered to install the air-vapour barrier when it was needed. I was able to do this and achieve 0.49 ACH at 50 Pa which was likely the tightest house built to that time. This of course presented other problems: how to provide air for ventilation? This problem resulted in the invention of the air-to-air heat exchanger for homes (which we know today as the heat recovery ventilator).

The problem in making the house air tight is not where we are able to install poly in large sheets but where the sheets are joined and where walls and floors intersect the large sheets. To this end we tried to eliminate these problem areas and make the other areas simpler. This has resulted in the "Prairie Double Wall."

The Prairie Double Wall

With exterior walls, the problem is making the poly continuous past interior partitions and floors, and with penetrations for electrical outlets and plumbing. In the Saskatchewan Conservation House we designed the house so that the exterior wall was the structure and the double wall was a light frame on the inside to make space for the insulation and to hang the interior finish on.

This seemed to me wrong because we should be designing for the best use of structural materials. If the inside wall is the structure the spans, for floor joists and the roof trusses don't have to be as great. This results in a larger house and the penalty is only a longer top cord on the roof truss and a few inches more siding.

One of the ways that super insulated walls had been insulated was to strap the inside of the wall and place the poly between the studs and the strapping. This had the advantage of moving the poly away from the inside wall surface but we had to be careful about the amount of insulation on the interior of the poly, to keep it above the dew point and avoid potential for condensation to occur on the poly.

We calculated that the safe ratio in Western Canada (on the Prairies) is about 1/3 - 2/3 and in Northern Canada 1/4 - 3/4. The disadvantages of using this system is that:

We lose floor space (2.3 to 2.8%).

Installing horizontal strapping is more work than building a second wall.

Dry wall on the exterior wall then should be installed vertically, perpendicular to the framing. As this is not normal procedure, it takes more work and the joints between boards are harder to hide than horizontal joints.

This idea was moved to the double wall. Why not install the poly on the outside of the inside wall in a double wall? This has the benefit of moving the poly further from the interior wall surface and gives more space for electrical wiring and other items that penetrate the wall than the 2x2 or 2x3 strapping. Moreover, since the wall studs are vertical, the drywall can be installed in the normal horizontal mode.

If the inside wall is the structural wall, the floor joists and the roof trusses can be supported by the inside wall and you get the best advantage for your construction material. The disadvantage of this is that the thicker exterior walls may have ramifications with clearances to property lines. You may also have some problems in supporting the outer wall and where do you install the wall sheathing? If the sheathing is installed on the outside of the outer wall it does not support the structural studs in the inside wall, and the poly on the outside of the inside wall is only supported by the insulation in the cavity. If the sheathing is installed on the outside face of the interior wall on the outside of the poly, you get the structural support for the wall and you get excellent support for the poly, but you lose backing for the siding. Since sheathing is not a major expense most builders install sheathing on both walls.

The double wall has a number of advantages over the single wall.

First, it has the ability to hold much more insulation. I have seen several houses built with 18" walls and these can hold R-60 (RSI 10.5) with fibreglass insulation or R-72 (RSI 12.7) with Roxul insulation. While these amounts of insulation are likely greater than today's optimum they may not be in the future. The effective R-value is higher too, because of the insulated thermal break of the insulated gap in between the two framed walls.

Secondly, the Prairie Double Wall uses thin sheet material on the top and bottom of the wall to hold the inner and outer walls together. This makes the wall higher than a conventional wall by twice the thickness of the sheet material. We originally used 5/16" plywood but now we usually use 8 mm OSB. In any case the walls are between 5/8" or 16 mm higher than a conventionally framed wall. This raises the floor to ceiling height by this amount.

If the ceiling air vapour barrier and drywall can be installed before the interior partitions are installed, the air vapour barrier can be installed in large sheets with no breaks and the ceiling drywall can also be installed in large pieces. This technique saves a lot of time and materials in installing ceilings, and I think it should be used in conventional construction because of the savings of time and materials. I have seen two drywall people install a 1,400 sq. ft ceiling in about 3 hours. In low energy housing however the use of large sheets of air vapour barrier without breaks results in much tighter ceilings and with much less effort.

Third, if you are installing floor joists or roof trusses on top of the walls you have a very handy platform for doing this work.

Fourth, the rooms that have windows look considerably larger than the same room with single walls because the windows look like bay windows from the inside, and entries are considerably larger because the door is moved away from the entry.

Fifth, the windowsills are great for plants and in 16" and thicker walls they make wonderful seats.

Sixth, because the air-vapour barrier is on the outside of the inside wall, it can be installed very quickly because there are no intervening partitions, and the electricians do not have to use poly pans or other means to seal the air-vapour barrier around the electrical boxes – a saving in both materials and labour.

Seventh, the structural wall is the inside wall so that the full structural capacity of the joist material and roof trusses can be utilized, and the wall thickness does not reduce the size of living space.

The need for more insulation to reduce heat loss from buildings can be achieved in various ways and each of has its advantages and disadvantages. The Prairie Double Wall holds the record for the tightest houses (0.12 ACH@50 Pa), and it has the lowest cost per unit of insulation with the possible exception of straw bale houses.

Because air tightness is more important for the reduction of heat loss than any amount of insulation or any other single component of heat loss, the Prairie Double Wall achieves both extraordinary reductions in heat loss through walls and reduces heat loss by air leakage to a very low value. This idea has been extended with modifications to existing housing with great success.

How to build a double wall

(the way I like to do it)

- The interior wall of the double wall is built exactly the same as the normal exterior wallof a house with minor exceptions. (I have underlined the exceptions.)
- I like to first chalk a line on the subfloor exactly where the inside surface of the wall will be placed. This will normally be 3½" inside of the outer edge of the floor header.
- The top and bottom plates are laid parallel to the chalk line. Put all 4 plates for both walls together.
- Mark window and door openings on the plates. (Make the rough openings ¾" larger than normal.
- Mark locations for studs, cripples etc. on all four plates. (At wall intersections I use 'ladder rungs' between the end stud and the next stud at end walls, and between studs on either side of partitions. The 'ladder rungs' provide backing for drywall, make it easier for electrical wiring, use less wood and make stronger joints between walls and make it easier to insulate these connections.)
- Cut the plates to length and place the bottom plate for the inner wall, against the chalk line and the top plate for the inner wall, parallel but a stud length away from the bottom plate.
- Cut window and door headers (¾" longer than normal) and fasten them together and nail in place to the top plate.
- Cut cripples for the window and door headers and install under the headers. (Cripples for doors should be 3/8" longer than normal.)
- Cut sill plates for under the windows (¾" longer than normal) and cut short studs for under the sill plates (¾" shorter than normal) and nail short studs to sill plates and bottom plate and nail window sill plates to cripples and then nail cripples to doubler studs.
- Install all common studs in place and nail to the top and bottom plates. Cut and install 'ladder rungs' at the end of the wall and where partitions meet. If the partition meets at a stud, leave the stud out and use double length rungs.
- Install the second top plate on the wall.
- Straighten the wall and square the wall as it is lying on the floor in preparation for sheathing. Before installing the

sheathing, cover the wall with the poly air-vapour barrier. The poly should extend at least 6" beyond all edges of the wall.

- Install the sheathing on top of the poly. (When cutting the sheathing be very careful not to cut the poly)
- Exterior wall The exterior wall is built on top of the inner wall using the inner wall as ajig so that they both match.
- Place the top and bottom plates in place on the interior wall. (The plates for the outer wall are likely longer than the plates for the inner wall by the space between the walls plus 3½ inches (89 mm).)
- Place studs beside the window and door openings. (These studs do not need to be cut like the cripple studs in the inner wall but may be full length.)
- Cut headers (¾" longer than normal) for above the windows and doors. These headers may be 2x4's and may be installed on the flat since the only load they are carrying will be the siding above the window or door.
- Install the remainder of the studs and short studs below windows and between top plates and window and door headers
- Cut spacer blocks the length of the space between walls and set these blocks between the inner and outer walls. (Do not fasten these blocks as they will later be removed.)
- Carefully align the window and door openings of the outer wall with those of the inner wall, and then nail strips of 3/8" (9mm) plywood or OSB to tie the top and bottom plates together and also line the inside of all window and door openings. (This is the reason for the ¾" (19mm) extra space in window and door openings.) The width of the plywood or OSB should be the space between the walls + 2 x 3½" + 3/8". If the space between the walls is 5½" for R-20 glass fibre or R-22 mineral fibre the strips would be 5.5 + (2 x 3.5) + 3/8 = 12.875". I like to compress the middle layer of insulation slightly so the there are no vertical air channels to set up convection cells in the walls, so I normally reduce the wall thickness to 12".
- Remove the spacer blocks previously installed between the walls.
- The space between the walls is now insulated by threading batts between the studs in the outer wall, and then the outer wall is insulated by placing batts in the outer wall.
- With the wall insulated it is sheathed with 3/8" (9 mm) plywood or OSB.
- Cut the poly in the window and door openings at 45 degrees at the top of the windows and doors and at the bottom of window openings. The poly is then patched in the corners as the poly flap (skirt) on the window or door is carried to the inner surface of the wall where it will be joined to a collar of poly installed and sealed to the window frame.
- When the Poly has been installed around the window and door openings, the sheathing strips are installed around the window and door openings to hold the two walls at the correct spacing, to protect the poly around the openings and to reduce the openings to the correct size for the windows and doors.
- The wall is now ready to be stood up. Because it is more than twice as heavy as a normal outside wall you may need wall jacks or more bodies to do the lifting.
- One of my concerns in lifting the wall is the possibility of the wall sliding off the floor. This is a serious inconvenience if the floor is one or two feet above the ground but a catastrophe if it is eight or more feet above the ground. This can be avoided if metal straps are nailed to floor across the chalk line in step 1 and when the wall is ready to be raised it is positioned against the chalk line and the metal straps are then nailed to the bottom plate. The straps become hinges keeping the wall in place but allowing it to be raised.)
- I only mention it here but I am not prescribing any particular system of bracing the wall. It is very important to have temporary braces in place to fasten and hold the wall so that wind will not blow it over until the other walls, and other structural components are in place to provide this function.
- With the wall erected, electrical wiring, plumbing and other mechanical components can be installed in the interior wall. Since the air-vapour barrier has already been installed there is no need to use poly-pans or other means to make the electrical or mechanical components airtight. This can be a significant cost savings.
- The wall can now have the inner layer of insulation installed.
- Finally, the interior wall finish can be installed. Since the inner wall does not have any poly on the inner surface, adhesive can be used to install the interior wall finish if desired.

Canadian Home Builders' Association

Technical Research Committee News

National Building Code Changes

Proposed changes to the National Building Code (NBC) are now available for public review. The purpose of this public review is to provide Code users and stakeholders with a detailed look at proposed technical changes, and seek comment on each proposed technical change. Every comment submitted gets careful review by the relevant committees. If approved by the Canadian Commission on Building and Fire Codes, the changes will be published in the 2015 editions of the NBC.

To access the changes, google the Canadian Codes Centre. Because of the cyber security issue, you will need to download a copy of the changes, but comments can be entered on-line. You will find full instructions on the site.

Code users and stakeholders are encouraged to participate in the review. The deadline is October 31, 2014.

CHBA's Technical Research Committee - Working for Home Builders

CHBA's Technical Research Committee is a national forum for sharing information on the technical aspects of home building. For more than 40 years it has identified technical issues and reviewed developments in technical research and in the regulation of housing technology. With some 40 members representing all aspects of the housing industry, TRC brings together home builders, government researchers, code and standards developers, warranty providers, material and product suppliers, academics and other experts. With few exceptions, members cover their own expenses to attend the meetings. The agenda is determined by homebuilders with provincial HBA representatives forming its management committee.

Federal Involvement in Housing Research

The federal government spends millions of dollars each year to improve the technical performance of housing. This includes research and information transfer activities at Canada Mortgage and Housing Corporation (CMHC), energy-related research and housing programs at Natural Resources Canada (NRCan) and building performance research at the National Research Council (NRC). In recent years Health Canada has also become involved in housing-related research, and increasingly, federal research funding is channeled through universities and colleges.

Some may wonder why the federal government is involved in housing research at all, given that housing is a provincial responsibility, or feel that housing research should be paid for by the industry itself. Others, including some builders, may think that housing research inevitably leads to more regulation and higher costs which consumers are not willing to pay for. However, the benefits of a national approach to technical issues, supported by federal research are significant and all stakeholders need to consider these.

Sound Separation - A Case Study

The new sound separation requirements in the 2015 National Building Code provide a good case study of the benefits from a national approach to housing issues. Noise between apartment units is a major cause of dissatisfaction among condominium buyers. Research done at the National Research Council (NRC) has greatly expanded our knowledge of how to reduce flanking noise between units cost-effectively.

This knowledge and the design tools developed by the research team represent decades of work costing millions of dollars. While a significant portion of these costs was funded by the material and product producers, the federal government's investment in research was considerable.

It is clear that designers, builders and condo buyers benefit from improved knowledge of how to increase sound separation between attached dwellings. Designers need to be able to accurately predict the acoustic performance of wall and floor assemblies more accurately, so that occupants will experience less noise disturbance from neighbours, and builders can defend their building practices in the event of warranty or legal action.

Without the leadership provided by the NRC, this important research would not have been done. For the housing industry's capacity to design and build cost-effectively to continue improving, continued federal investment in housing R&D is essential.

A key aspect of this federal research was its testing of construction assemblies reflecting the different building practices used across the country. This is far more efficient and cost effective than relying upon each province to carry out its own research,- and also protects against unnecessary divergence in provincial codes. In this case, the researchers worked with CHBA and its builder members to identify current regional construction practices.

At the end of the day, researchers did not expect the industry would broadly adopt the new, more complex measures unless it 'had to'and so proposed these changes become requirements within the code.

CHBA argued that the new requirements should apply only to large buildings initially -- those where engineers are necessarily involved. This would create a pool of designers and building officials with experience with the new measures which could then ease their introduction to Part 9 buildings in fairly short order. Given that the new tools make it possible to optimize assemblies to reduce ineffective practices and save money, all building types can benefit from their application.

Ultimately, the Canadian Commission on Building and Fire Codes (CCBFC), which oversees the development of the NBC, decided to apply the requirements to both large and small buildings in the 2015 NBC. Reflecting this, a committee that included homebuilder representatives was formed and tasked to prepare the new provisions.

Some might argue that builders would have been better off had the research not been done given that the new requirements which resulted may lead local authorities to demand the involvement of engineers to certify compliance. It is possible that some builders would prefer to spend money on over-designed wall assemblies rather than having the approval process become more complicated and expensive.

In my view the new requirements should have been deferred until the 2020 NBC for small buildings. However, given the decision to include them in the 2015 NBC, CHBA and its builder members had a major impact on the final form of the requirements making them as straightforward as possible.

Builder representatives were directly involved in developing the final provisions and in heading-off a proposal to increase the minimum performance level. In response to CHBA concerns, NRC staff developed a relatively simple prescriptive compliance path that should eliminate the need for engineers to be involved.

Finally, CHBA arranged to have the new rules field-tested before they were adopted. CHBA-National and CHBA-Alberta collaborated to bring builders, designers and building officials together to give the proposed requirements a 'test-drive' and this resulted in clearer wording in the Code.

Benefits for Builders

The 'test drive' of the proposed sound separation requirements simply would not have happened without the TRC being in place. The network forged between builders across the country and between builders and code developers and researchers would simply not exist without the in-person TRC meetings. CHBA staff would be less in-tune with builder priorities and would have far less credibility with governmental departments without having builders directly involved. The fact the TRC exists is the reason that CHBA was given an extra seat at the Part 9 code committee and a key reason for the respect it receives at the codes centre and other technical forums.

CHBA's ability to influence government research agendas would be severely hampered without TRC. From my experience as CMHC's representative on TRC during the 1990s, I know that government research priorities are set with TRC in mind and projects are expedited in anticipation of TRC meetings. Without TRC as a focal point, federal research and information transfer resources would be less responsive to builder needs and priorities. ☼

This piece was contributed by Don Johnston.
Don Johnston retired from CHBA at the end of 2013 where he had been responsible for coordinating the activities of TRC as the Senior Director for Technology and Policy since joining CHBA in 1997. Previously he was the Director for Technical Research and Policy for Canada Mortgage and Housing Corporation. Don received his professional degree in architecture from McGill University in 1971.

Energy Answers

Rob Dumont's Directives For a Decent Energy Efficient Home

This is part 2 of Rob Dumont's Directives For a Decent Energy Efficient Home. Last issue we presented the first 10 points. Here we present the next six points.

Rob Dumont

11. Air tightness and mechanical ventilation with heat recovery. Build tight and ventilate right. The R-2000 air leakage standard of 1.5 air changes per hour at 50 pascals is now readily achievable by many Canadian builders, and some have called for an air leakage rate as low as 0.5 air changes per hour at 50 pascals. However, it is important to have the house tested for air leakage.

Remember that airtightness is not just an energy concern, but also reduces moisture problems caused by uncontrolled air leakage.

Tight homes must also have a designed ventilation system. Some jurisdictions have mandated the use of heat recovery ventilators. Select an HRV that has a low electrical consumption.

The Heating and Ventilation Institute is the independent agency that certifies ventilation equipment performance. Product performance test results are published in the HVI directory available on the HVI website: *www.hvi.org*.

For heat recovery ventilators, high efficiency (effectiveness) is important. Efficiency in the CSA C439 test standard (used for HVI Certified Products directory) is the *effectiveness* less the energy used by fans, defrost, energy gains through casing and any cross leakage. There are some highly effective HRVs that have a lower efficiency due to poor motor/fan performance. European testing lists efficiency, but in North American terms it is really *effectiveness*. Fans and other energy use is captured elsewhere in their home energy calculation software. Appropriate sizing, air balancing after installation, and the ability to adjust between high and low speed as ventilation needs increase or decrease is important, as is the availability of spare parts and knowledgeable service personnel.

12. Low-emission materials

Indoor air quality is also achieved by avoiding materials with high emissions. The solution to pollution is not dilution, but source control.

My house used building materials that have low off-gassing of volatile organic compounds (VOCs) and formaldehyde. Particleboard, which contains formaldehyde, was not used. Kitchen cabinets and bathroom vanities had the frames made of birch plywood. Prefinished hardwood floors were nailed to the subfloor. No wall-to-wall carpets were used, although some smaller area rugs are used. Low emissions (no VOC) paints were chosen. Ceramic tiles were used instead of vinyl sheet flooring.

The preferred type of vacuum cleaner is a central vacuum that vents to the outdoors. Most regular vacuums tend to blow a lot of dust around the house, but a central vacuum does not have this problem. At the framing stage, rough in the plastic ducts for a future central vacuum to be installed.

13. Space Heating and Domestic Water Heating

Keep the space heating and water heating systems simple. No matter how interesting new innovative systems may be, the reality is that complex mechanical systems almost always are problematic, expensive and unreliable, and often do not deliver the promised efficiency. Perhaps the most trouble-prone example has been seasonal heat storage systems that attempt to capture and store large amounts of energy between seasons. While technically feasible, such systems are usually very expensive, produce nominal savings and may require the homeowners to adopt a full-time repairman as a live-in family member.

Space heating and water heating equipment should be efficient and reliable but not require unusual professional maintenance.

Directives For A Decent, Energy Efficient Home

1. Design
2. Lot Selection
3. House Shape
4. Design for flexibility
5. Trees
6. Garage Type
7. Contractors
8. Windows
9. Thermal mass
10. Insulation levels
11. Air tightness and mechanical ventilation with heat recovery
12. Low-emission materials
13. Space Heating/Cooling and Domestic Water Heating
14. Renewable Energy
15. Cooling/Air Conditioning
15. High Efficiency Lighting.
16. Efficient Water Use.
17. Energy Star Appliances
18. Safety
19. Durability
20. Think multiple uses, low impact materials

For instance, some tankless water heaters incorporate heat exchangers that must be acid washed each year by a professional to remove scale build-up from the water in the heat exchanger in order to keep the unit operating properly and the efficiency high. In areas with high mineral content in the water this scale build-up is a serious problem. The cost of the regular visit by a professional plumber to do the acid wash will most likely exceed the saving in energy costs.

Consult with a space heating and plumbing contractor or other specialist to select equipment available in your region with a track record of efficiency, reliability and low maintenance. The Energy Star web site lists heating and domestic hot water equipment with certified high efficiency.

With very energy efficient houses, the space heating demands are modest. For instance, in my home, which is rather large at 1100 square feet (102 square metres) per floor and 3 floors (two storeys plus a full basement), the peak space-heating requirement is 5.5 kilowatts (18,800 BTU/hour) at -34°C (-30°F). For comparison, the 4 electric elements on our kitchen range are also rated at 5.5 kilowatts.

The CSA standard for sizing heating equipment has recommended that the furnace output be no greater than 40% higher than the peak heating requirement. It is difficult to buy an efficient furnace small enough for that low a heat output.

Oversized heating equipment has several problems: the equipment is noisier, larger ductwork is needed, the equipment cycles on and off too frequently, and the rapid cycling causes premature failure of vulnerable parts such as relays and electronic igniters for fossil fuel furnaces. Short firing cycles also can result in more frequent condensation inside the furnace and venting system. Condensation causes corrosion unless the parts are specially designed. Short firing cycles also mean that rooms located at a distance from a forced air furnace will not heat up, as the cold ductwork needs a long firing cycle to heat up satisfactorily.

Some small super-insulated low energy houses have been heated with a single natural gas or propane fireplace or an oil-fired space heater. These heating appliances are point sources of heating, but the heat may not be evenly distributed throughout the house if the house has multiple storeys or is divided into small rooms.

A 4-unit multiple residence in Regina was recently retrofitted with super-insulation, improved air tightness and a heat recovery ventilator. Each of the units in the building was supplied with a single natural gas fireplace in the living room to replace the old heating equipment. The units were of modest size, with each having a floor area of about 1000 square feet (93 square metres). Each unit has mostly an open floor plan, except for the bedrooms and bathrooms, and heat will circulate to the rooms in each suite by natural convection as long as the doors are open.

As a backup, each bedroom was supplied with a small, thermostatically controlled 500-watt electric baseboard heater. (As the units are rented out, the owner told me that because the tenants pay the electricity bill but not the natural gas bill for the fireplaces, the electric baseboard heaters are rarely if ever used.)

Another heating technology being used by some advanced designers is a mini-split heat pump designed for cold temperatures. Several Japanese companies make these units. They also can serve as air conditioners in the cooling season.

Some very low energy houses have used ground source heat pumps. However, while somewhat more efficient, ground source heat pumps tend to be considerably more expensive than air source heat pumps.

14. Plan for the use of **renewable energy** technology devices such as solar water heaters and photovoltaic panels by orienting a roof surface toward the south at a tilt angle roughly equal to the latitude angle plus or minus 20 degrees at your geographic location. (Example: Saskatoon is at latitude 52 degrees north. A south-facing surface tilted between about 32 and 72 degrees from the horizontal will be close to the optimum for solar collection.) One reviewer with experience in PV installations on the Canadian prairies stated that a 60-degree tilt angle is a good angle in the lower part of Canada.

An engineer experienced with PV installations recommends that PV panels be mounted at least 6 inches (150 mm) above the roof in order to keep the PV panels cooler and more efficient. Choose PV panels that have a guarantee as to their output and are rated by a third party agency. Given Saskatchewan's current (2014) electricity price of 13.8 cents per kilowatt-hour, a low maintenance, high quality solar photovoltaic

system amortized on a mortgage is now competitive with grid supplied electricity. During the lifetime of the house, electricity generated by solar photovoltaic panels will very likely become less expensive than grid electricity in most parts of the world. Plan for it.

15. Cooling/Air Conditioning. The first thing to do to provide efficient cooling is to limit the sources of heat gain.

Use efficient LAME (lights, appliances and miscellaneous electricity). Also, limit solar gains through un-shaded windows, which are often a major source of unwanted heat gain during the cooling season. Un-shaded west facing windows can be the worst, as they add heat during the warmest part of the day. East-facing windows should also be minimized. Shading devices on the outside of the windows are much better at excluding unwanted heat than shading devices such as interior venetian blinds or curtains.

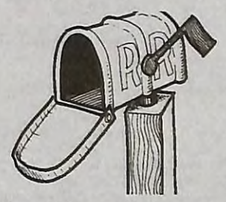
With climate change, we are likely to experience hotter days, which will add to the cooling load. In many parts of Canada during the cooling season the outdoor air temperature at night will fall below 20°C (68°F). This cooler night air can be brought into the house to provide inexpensive cooling. In the author's house, a window-mounted fan is used to blow this cooler outside air into the bedrooms at night.

16. High Efficiency Lighting. Use natural lighting, light the task rather than the whole room, and use light coloured walls and ceilings.

Compact fluorescent lamps (CFLs) and light emitting diode (LED) lamps are recommended. Choose Energy Star-rated lamps. LED lamps are preferred as they typically have a longer life than CFLs and do not contain any mercury. Most LED lamps are also dimmable and can be used outdoors. Choose warm white LED Lamps with light output levels of 80 to 100 lumens per watt. The technology is quickly evolving, with many new and improved products coming on the market, resulting in dramatic price reductions.

As with any lamp, be sure that they are suitable for enclosed light fixtures. Enclosed light fixtures will build up heat and can damage many lamps or be a fire hazard. Large, linear fluorescent lamps (2 or 4 foot long T8 lamps) are all right for some applications in a home, but when the ballast fails an electrician is often required.☼

To be continued next issue.



Letter to the Editor

Re: Energy Answers, Solplan Review 175

I read Rob Dumont's article with great interest and found it an excellent summary of the topics until I read his suggestion that beadboard is OK for insulating below a concrete floor!

Beadboard is about as water resistant as popcorn!! I know I am exaggerating, but expanded polystyrene (EPS) will absorb quite a lot of water over time, which will seriously degrade its R-value. Ask Joe Lstiburek about his early adventures with beadboard below grade.

At least some mention of the need for a moisture barrier below the beadboard would have been wise, but the better choice is still, and always has been, extruded polystyrene (XPS) regardless of the extra cost.

One other thing. I agree that a perimeter thermal break is an excellent final touch but with shallow basements in BC it has been known for termites to eat their way up through the beadboard and invade the space between the concrete wall and the wall insulation and on up to the sill plate. So, a mention of employing a denser insulation, such as spray foam, at this location would be good.

Peter Meridew
Nanaimo, BC

It is worth remembering that EPS has several densities, so below ground you would want to have the higher density material. Although EPS will absorb some moisture, it still is used as a floating element for boats and floating docks, and is used for insulated concrete forming (ICFs). However, it is worth keeping in mind.

And of course, site specific conditions should always be considered. When building in wet soils and areas with heavier rainfalls, the water absorption is a more important criteria to material selection than in dryer areas and also well drained highly permeable soils.

The termite issue is also site specific as not all regions face this problem. However, slab-edge insulation is important and has now been introduced into the building code. High density spray foam may not be the answer in that case either. Where termites or other critters are an issue, all available options need to be considered. Ed.

Mini-Split Heat Pumps

Heat pump technology has evolved in recent years.

Heat pumps move heat energy from one location to another, typically moving the energy opposite to the natural direction of heat flows. They absorb heat from a colder location and release it into a warmer space. Some energy is used in the process of doing the work.

Although we may not think of them as such, air conditioners, refrigerators and freezers are examples of heat pumps we've been relying on for many years. However, technically the term can be used more generally in heating and ventilation systems. Increasingly heat pumps are used in heating and ventilation and cooling systems in residential applications.

When a heat pump is used for heating, it uses the same refrigeration-type cycle used by an air conditioner or a refrigerator. In heating applications, it works in the opposite direction – drawing air from the exterior air (or ground for ground-source units) and releasing heat into the conditioned space rather than to the outside.

North American heat pumps up to now have primarily been configured for cooling applications. In other parts of the world, they have been used to provide both cooling and heating. Several Asian manufacturers have begun marketing their units in North America. These have been promoted as doing double duty – heating and cooling.

Their new generation of inverter-driven mini-split heat pumps have been dubbed as "ductless heat pumps" in recognition of their differences from conventionally ducted systems. These systems use small wall-mounted air handlers with direct refrigerant supply from a compressor located outside. They promise high levels of energy efficiency (much greater than conventional North American heat pumps) as well as increased comfort, quiet low-noise operation, and ease of installation.

From a comfort standpoint, these systems have a number of attractive features including variable output strategies that allow for high starting temperatures so that occupants feel "instant heat" when the systems come on; both indoor and outdoor units that are virtually silent under normal operation; and a range of operation that delivers significant heating capacity even down to low outdoor temperatures (below -12°C or 10°F). These features combined with high efficiency present an opportunity to use the heat pump units to serve as a primary heating system with minimal, if any, backup use of electric resistant heat.

As the new generation of equipment was introduced, it was apparent that the equipment can be substantially more efficient than conventional split-system heat pumps with central air handlers and a central ducting system. In addition, these systems are low enough in cost and flexible enough to be considered as a measure to offset electric resistance heating systems, which are not easily retrofitted with ducting systems.

Ductless mini-split heat pumps are especially interesting to electrical utilities as they provide a higher level of energy efficiency and offer the potential to reduce demand in electrically-heated buildings.

The Northwest Energy Efficiency Alliance (NEEA) in the US (Washington, Oregon, Montana and Idaho) undertook a study to determine the performance of the ductless mini-split heat pumps in their region. The study ran from October 2008 through December 2009, with a total of 3,899 installations. In the project, the ductless mini-split heat pumps were meant to supplement existing electric baseboard heating systems. This way, the occupant interaction is left to chance; i.e., the occupant is able to reset the equipment, adjust the thermostat remotely, and change the load on the equipment through the use of the electric resistance heating or a supplemental heating system. The monitoring included the best form of monitoring – an analysis of utility billing.

Heat pump ratings rely on single point performance ratings and are published in accordance to guidelines specified by the US Department of Energy (DOE) and Air-Conditioning Heating and Refrigeration Institute (AHRI). The rating points, such as the heating seasonal performance factor (HSPF) and seasonal energy efficiency ratio (SEER), depend on a single curve describing the performance of the equipment over a temperature range that is essentially continuous and predictable.

For conventional heat pumps the single rating point is marginal, at best, for determining

energy use. And although the AHRI standard has specific tests for variable speed equipment, it was noted that the standard ratings do not represent the typical performance of ductless mini-split equipment as it responds to the range of conditions that drive variable speed operation of the system components. Existing field tests show that ductless heat pump technologies often perform better than the ratings suggest by optimizing the outputs and inputs to the current environmental conditions.

In addition to monitoring installed equipment, lab testing was done to establish the efficiency and performance of the equipment at various outside temperatures.

The lab testing of two different manufacturers products compared well with actual field measured coefficients of performance (COPs) across a range of temperature conditions and largely validates that manufacturer ratings of this equipment are accurate. With seasonal COPs ranging from 2.4 to 3.4 and an average of 3, the inverter driven technology delivered high performance.

Monitoring Results

The average energy savings across the metered sample exceeded 3,800 kWh per year. Even when comparing heating energy use after the heat pump installation to heating energy use before, the evaluation measured a "net" energy usage that was significant though less than measured directly from COP measurements.

The difference between the savings observed in the metered sample and the billing analysis sample was attributed to roughly 20% of the heat produced by the heat pump being used to provide other benefits (beyond energy savings) to the occupant. These benefits included higher temperature set-points in the main living space, reduced supplemental fuel consumption, increased temperatures in adjacent secondary living zones, and increased occupancy during the heating season.

The overall savings from the simple billing analysis of the pilot project group can be divided into two categories. First, the unscreened version of the billing analysis averaged across all climates and all space heating types, showed approximately 1,900 kWh/year in energy savings.

When this same group is screened for supplemental fuels, as identified in the customer interview conducted at the time of the installation of the heat pump, the savings estimates increase to about 2,700 kWh/year – a better than 30% increase in savings. This result compares reasonably well to the billing analysis conducted in the metered sample, where more careful screening of supplemental fuels was done. In that sample, the billing analysis suggested that space heating savings or the energy savings from the heat pump installation were approximately 3,100 kWh/year. However, when error bounds are taken into account, there is not a statistically significant difference between the billing analysis savings estimates for the overall pilot population and for the subsample of metered sites.

The billing analysis for the overall project is fairly conclusive on two main points:

1. The use of supplemental fuels by customers with zoned electric resistance hea, leads to substantial reduction in savings - on the order of 30% or more.

2. In colder climate heating zones in the eastern part of the US Northwest, a more careful engineering analysis may be appropriate to specify systems that are more likely to produce a similar level of savings as those observed in the milder western climates. This research would likely include the introduction of a second indoor air-handler unit and/or the introduction of a higher capacity compressor in these colder climates.

The study points out that these types of heat pumps can appreciably offset electric space heating requirements in simple electric resistance systems without disrupting the existing heating system or underlying home structure.

It was also noted that manufacturer ratings for the heat pump do not appear to have a significant impact on the savings. With few exceptions the savings were similar across manufacturers and models regardless of the nameplate capacity or efficiency ratings. This suggests that the technology is adaptable to a utility program with the goal of providing improved heating efficiency and energy savings resources, but the savings are strongly determined by the amount of pre-existing electric heating,– since the study was looking at retrofits.

Average savings of 33% were observed across the entire US Northwest. Higher savings were observed in the milder, western area, and lower savings were observed in the more severe heating climates.

Final Summary Report for the Ductless Heat Pump Impact and Process Evaluation February 2014, Report #E14-27
Prepared by: Ecotope Inc. Seattle, WA 98105
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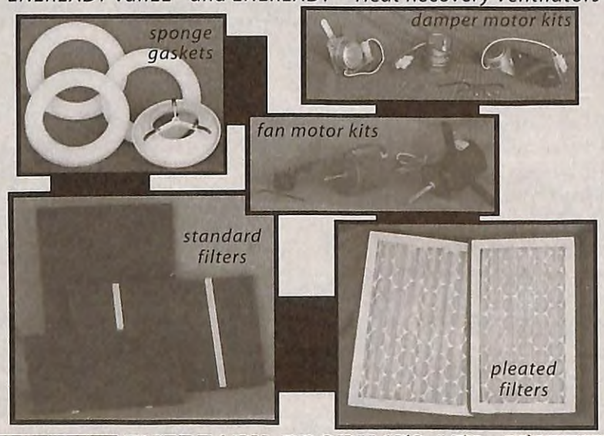

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BC Building Code Introduces New Radon Rough-in Requirements

Effective December 19, 2014, the BC Building code will require the rough-in for a subfloor depressurization system and the installation of a radon vent pipe which extends through, and terminates outside, the building. However, the code will not require the installation of a fan during initial construction

The new requirements allow for future radon mitigation and require the designer to account for routing of the radon vent pipe during the design stage. This change will apply to Part 9 dwelling units and buildings containing residential occupancies where floor assemblies separate conditioned space from the ground. It is still the owner's responsibility to test their home once completed, and it is recommended that the home be tested again after installation of a radon mitigation system.

The change was made because the potential for high levels of radon infiltration can be challenging to evaluate prior to construction and a radon problem may only become apparent once the building is completed and occupied.

Radon mitigation systems are proven to reduce the likelihood of adverse health effects from radon, such as lung cancer, and a number of areas in BC have been shown to have high radon concentrations.

The most common and efficient radon mitigation method is soil depressurization. A soil depressurization system requires:

- An air permeable ground to allow for the movement of soil gases under the on-grade air barrier system into which a radon vent pipe is placed.
- A radon vent pipe that extends to the outside of the building and terminates in a safe location,
- A fan installed along the radon pipe, to create a negative pressure under the house and exhaust soil gases outside the building.

The provisions for a radon rough-in during initial construction require a small cost and effort at the time of construction to reduce the much larger cost of retrofitting a radon mitigation system after construction. The requirements provide added benefits of improved sub-slab drainage and integrity of the air barrier system.

Information

RadonAware, British Columbia Lung Association (*www.radonaware.ca*)

Canadian Government publications (available at *www.publications.gc.ca*)
Radon: A Guide for Canadian Homeowners 2007
Guide for Radon Measurements in Residential Dwellings (Homes) 2008
Radon – Reduction Guide for Canadians

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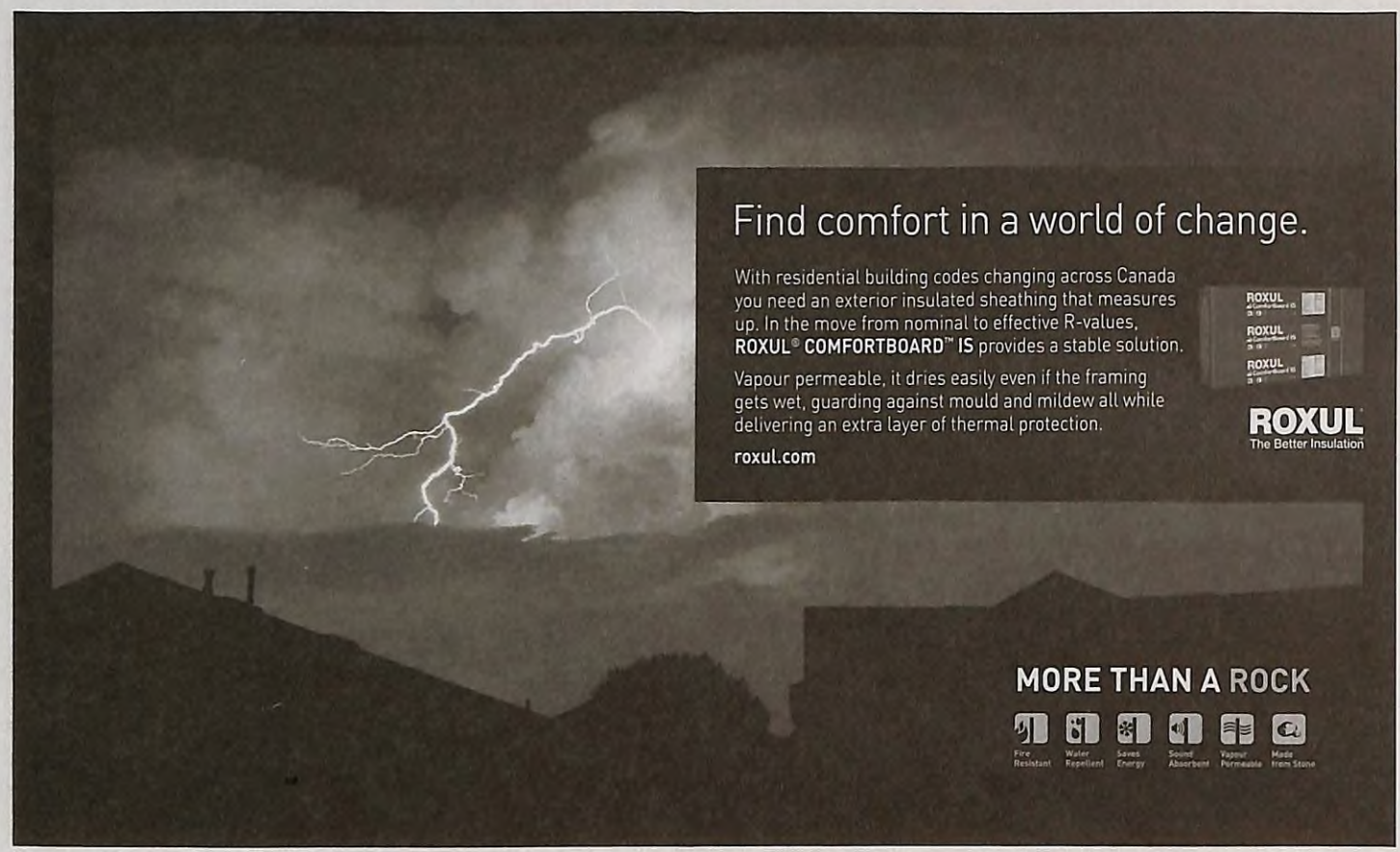
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